



## Generational and Gender Variation in the Acoustic Realization of Korean Coda /l/

Yeseul Lee · Ilgwon Sohn (Kyungpook National University)



This is an open-access article distributed under the terms of the Creative Commons License, which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

Received: August 19, 2025

Revised: September 11, 2025

Accepted: September 16, 2025

Lee, Yeseul (First author)  
MA student, Department of  
English Language and Literature,  
Kyungpook National University,  
80 Daehak-ro, Buk-gu, Daegu  
41566, Republic of Korea  
Email: leeelim13@gmail.com

Sohn, Ilgwon (Corresponding  
author)  
Professor, Department of  
English Language and Literature,  
Kyungpook National University,  
80 Daehak-ro, Buk-gu, Daegu  
41566, Republic of Korea  
Email: igson@knu.ac.kr

### ABSTRACT

Lee, Yeseul and Ilgwon Sohn. 2025. Generational and gender variation in the acoustic realization of Korean coda /l/. *Korean Journal of English Language and Linguistics* 25, 1281-1298.

This study analyzes generational and gender-based variation in the acoustic realization of Korean coda /l/, focusing on how the manner and place of the following consonant condition velarization and retroflexion. The full formant trajectories (F2, F3) and relative indices (F2-F1, F3-F2) measured for 40 native Korean speakers in two age groups were analyzed using Generalized Additive Mixed Models. Results showed that younger speakers exhibit more advanced velarization and retroflexion consistently across acoustic measures. Female speakers show robust generational differences across most manners and places of articulation, with the strongest effects in bilabials, alveolars, and nasals, although gestures are suppressed in fricatives. Male speakers, by contrast, show fewer and more context-specific differences, largely restricted to stops and affricates, with significant shifts only in bilabials. These findings support the gender-differentiated diffusion theory, indicating that female-led changes are more advanced, whereas male realizations are more constrained by articulatory context. Overall, the results underscore the role of generational change in the ongoing phonetic shift of Korean coda /l/ and highlight the importance of considering gender and articulatory environment in models of sound change.

### KEYWORDS

Korean coda lateral, velarization, retroflexion, gender differences, generational differences

## 1. Introduction

Previous studies on the phonetic realization of the Korean liquid /l/ have primarily focused on articulatory environments such as syllable position and following consonants, as well as speaker-related factors. While these studies have described the distribution of allophones and articulatory features across phonological environments, few have undertaken a systematic investigation of generational variation in pronunciation. Most studies have categorized the allophonic variation of /l/ into two forms: the alveolar lateral [l] occurring in coda position before consonants, and the tap [ɾ] realized between vowels.

Recent findings suggest that the Korean lateral exhibits complex variability. Crosby and Dalola (2021) report that Korean /l/ is prone to retroflexion in pre-pausal positions and that preconsonantal [l] often carries retroflex features. Palatalized laterals [ɭ] also occur before high front vowels or glides (/i, j/). The present study concentrates on coda /l/ before consonants, where its acoustic profile aligns more with retroflexion than with tapping. F3 trajectories show sustained lowering, unlike the brief closure and release of taps. Supporting this interpretation, recent articulatory studies demonstrate that coda /l/ frequently involves tongue-tip curling or dorsum retraction (Crosby and Dalola 2021, Hwang et al. 2019, Lim et al. 2023). Accordingly, this study adopts retroflexion as the primary framework for analyzing coda /l/.

The articulatory variation of Korean /l/ can be broadly classified into two types: velarization, which involves tongue body retraction toward the velum, and retroflexion, which involves tongue-tip curling or tongue-body raising toward the velum. These two articulatory modifications often co-occur, jointly shaping the acoustic realization of laterals. In the case of velarization, retracting the tongue tip or blade enlarges the anterior cavity, leading to a decrease in F2, while the posterior cavity is reduced, thereby increasing F1. Consequently, the F2-F1 difference decreases (Mackenzie et al. 2018, Sproat and Fujimura 1993). In contrast, when the articulation remains alveolar as in clear [l], the anterior cavity is shortened, raising F2, and the posterior cavity is enlarged, thereby lowering F1, resulting in an increased F2-F1 difference.

Retroflexion, on the other hand, involves either the backward curling of the tongue tip or the elevation of the tongue body, which asymmetrically alters the vocal tract by lengthening the anterior cavity and shortening the posterior cavity. This results in a steep drop in F3, which may approach or even cross F2 (Espy-Wilson 1992). Lateral sounds thus exhibit diverse acoustic properties depending on their articulatory configuration and position. In particular, formant-based indices such as F2, F3, F2-F1, and F3-F2 serve as key acoustic indicators of articulatory variation in laterals.

In addition to articulatory and acoustic factors, sociophonetic variables also play a crucial role. Gender, in particular, is a well-established factor in conditioning sound change, with female speakers often spearheading innovations (Eckert 1989, Labov 2001). Evidence of generational shifts has already been reported for Korean laterals. Yun et al. (2017) showed that younger speakers articulate word-initial /l/ with weaker constriction, indicating a potential sound change in progress. Although their study focused on the initial position rather than coda /l/, it underscores the importance of considering both generation and gender in Korean phonetic variation.

This study aims to quantitatively analyze the acoustic variation of the lateral /l/ in coda position before consonants, focusing on four formant measures. To this end, the study addresses the following research questions:

- 1) Do generational differences exist in the phonetic realization of coda /l/ among Korean speakers?
- 2) Does speaker gender significantly influence the patterning of these generational differences?
- 3) Are generational differences in coda /l/ realization conditioned by the manner and place of articulation of the following consonant?

By addressing these questions, this study aims to demonstrate that the realization of the Korean lateral /l/ is not

governed by a fixed phonological rule but rather exhibits diverse acoustic variation. This variation is primarily influenced by speaker generation and further conditioned by gender and the phonological properties of the following consonant. To capture these patterns, the study employs Generalized Additive Mixed Model (GAMM, Sóskuthy 2017), allowing for a fine-grained analysis of how coda /l/ changes over time in relation to the following consonant. Rather than treating /l/ as a static phonological category, the study conceptualizes it as a flexible segment shaped by multiple interacting influences. The findings are expected to offer significant implications not only for theoretical accounts of Korean phonology but also for applied fields such as pronunciation instruction, speech recognition, and speech synthesis.

## 2. Literature Review

The Korean lateral /l/ shows considerable articulatory variation depending on syllabic position and adjacent segments. It is typically realized as an alveolar flap [ɾ] between vowels and as an alveolar lateral [l] in syllable-final or preconsonantal contexts. However, recent studies suggest that coda /l/ is not consistently realized as a lateral, but rather includes a range of allophonic variants such as flaps, approximants, and weak fricative-like sounds, depending on the phonological context. Real-time MRI studies reveal that its articulation systematically varies with prosodic structure, sometimes showing reduced or absent tongue body gestures (Lee et al. 2015). Acoustic and production studies also confirm that word-final /l/ is highly context-dependent and shaped by coarticulatory effects (Ahn 2017). Thus, although /l/ is phonologically represented as a single liquid in Korean, its phonetic realization is gradient and influenced by surrounding linguistic factors.

In addition to phonological and positional variation, previous work has also examined sociophonetic factors such as generation and gender. Yun et al. (2017) compared the pronunciation of word-initial laterals across generations and found that younger speakers tend to exhibit weaker lateral constriction, pointing to an ongoing sound change. Song (2020) investigated generational and gender differences in the VOT of English loanwords in Korean, although gender differences were not statistically significant in that study. While the study did not focus on /l/ specifically, it nonetheless demonstrates the relevance of considering both generation and gender in examining phonetic variation in Korean. These findings provide important motivation for the present study, which treats both generation and gender as key factors in analyzing the variation of coda /l/.

Beyond sociophonetic influences, articulatory studies have further demonstrated that the production of /l/ also varies systematically depending on phonetic context. Hwang et al. (2019), using ultrasound imaging, demonstrated that Korean coda /l/ can be realized as apico-dental, lamino-alveolar, lamino-postalveolar, or retroflex in word-final position. Similarly, Lim et al. (2023), using electropalatography (EPG), observed that Korean /l/ in loanwords is realized variably as a tap, lateral, or approximant, with the distribution depending on segmental and prosodic context. These findings imply that coda /l/ may also vary according to the type of following consonant. Kang (1999) found that Korean speakers tend to produce clear [l] rather than velarized [ɫ] in English word-final position, which is characterized by weak velarization and limited tongue retraction.

These articulatory patterns are further reflected in the acoustic domain. A number of studies have examined how formant structures represent articulatory variation in /l/ realization. Park and Jang (2016) reported that Korean [l] produced by L2 English speakers shows higher F2 values and slightly lower F3 values than native English clear [l]. This was attributed to increased tongue fronting, while Korean speakers' failure to sufficiently lower F3 in producing /ɾ/ resulted in an acoustic mismatch. Kang (1999) also found that Korean speakers made more errors in /l/ production than /ɾ/, particularly in word-final positions, often defaulting to a clear [l] with insufficient darkening.

More recently, Crosby and Dalola (2021) observed significant F3 lowering in retroflex coda /l/ realizations before sentence-final pauses, demonstrating that articulatory variation in coda position can be acoustically observable.

In addition to absolute formant values, relative acoustic measures have been proposed as robust indicators of /l/ quality. Turton (2017) found that lower F2-F1 values in simultaneous acoustic-ultrasound analysis were associated with greater tongue dorsum raising, indicating stronger velarization/pharyngealization. Kirkham (2017) further demonstrated a strong correlation between F2-F1 and perceptual ratings of /l/ darkness. Similarly, Chung (2021) found that F2-F1 values varied by approximately 50-80 Hz depending on discourse and syllabic context, suggesting that it functions as a gradient cue to /l/ darkness. However, Korean phonetic studies have rarely undertaken systematic evaluations of the theoretical validity and empirical robustness of these acoustic cues.

Based on prior studies, this study employs both absolute formant values (F2, F3) and relative acoustic measures (F2-F1, F3-F2) to capture articulatory variation in Korean coda /l/. Although F2 and F3 index tongue position and retroflexion, absolute values alone may inadequately capture gradient differences in velarization or retroflexion. Therefore, this study incorporates distance-based metrics to complement the analysis. The first measure, F2-F1, is perceptually salient: Heselwood (2009) demonstrated that velarization remains perceptible even under low-pass filtering that removes F3, indicating that F2-F1 provides sufficient acoustic information for retroflex perception. Lee-Kim et al. (2013) also reported that in certain vowel contexts, F2-F1 predicted perceived 'darkness' more robustly than F2 alone. The second measure, F3-F2, effectively captures retroflexion: Heselwood and Plug (2011) argue that perceptual salience depends on how closely F3 approaches F2 rather than the absolute lowness of F3. Turton and Lennon (2023), analyzing Lancashire English, proposed a critical threshold of approximately 3.5 Bark (roughly 400 Hz) between F3 and F2 for classifying a sound as /ɭ/, supporting the utility of this metric for assessing retroflexion in coda /l/.

Despite these findings, sociophonetic factors, particularly speaker generation and their interaction with post-liquid consonantal environments, remain largely unexamined. To address this research gap, the present study systematically analyzes F2, F3, F2-F1, and F3-F2 values across speaker generations and post-liquid consonant types, aiming to characterize generational variation in Korean coda /l/ realization.

### 3. Methodology

#### 3.1 Participants

Participants were native speakers of the Gyeongsang dialect in Korea, each with less than six months of overseas residency to minimize the influence of L2 exposure. A total of 40 participants were recruited, comprising two generational cohorts: 10 males and 10 females in their teens and early twenties (younger group,  $M = 20.9$  years), and 10 males and 10 females aged over 40 (older group,  $M = 54.3$  years). Participants were compensated for their involvement after completing the experiment.

This generational division follows established criteria from sociophonetics and phonological change research. Labov (1994, 2001), using the apparent-time framework, classified speakers under 30 as the generation leading language change and those over 50 as the conservative group. Likewise, Tagliamonte and D'Arcy (2009) proposed comparison groups aged 17-29 and 45+, based on the post-adolescent peak principle. Drawing on these precedents, the present study considers speakers under 20 and over 40 as exemplifying younger and older generational patterns, respectively.

### 3.2 Materials

To examine the acoustic variation of coda /l/, ten disyllabic Korean words were selected, each containing /l/ in the first-syllable coda followed by different onset consonants in the second syllable. This design is intended to systematically examine how the articulatory properties of the following consonant affect the realization of coda /l/. Onsets were selected to represent diverse manners and places of articulation, enabling comprehensive analysis of variation across articulatory contexts.

Certain consonants were deliberately excluded from the target word set to ensure reliable acoustic analysis. The nasal /n/ was excluded because liquid assimilation may produce [l] or [n], obscuring the independent effect of the following consonant (Sohn 2008). /l/ was also excluded because adjacent liquids can produce complex assimilation patterns, complicating acoustic analysis. Finally, /h/ was excluded due to its unstable formant structure, frequent deletion, and unsuitability for formant-based acoustic measurements (Koffi 2024).

The final ten target words were selected to ensure a balanced distribution of manners and places of articulation among the following consonants. The complete list of stimuli, along with the articulatory specifications of their post-liquid consonants, is presented in Table 1.

**Table 1. Target Words and Articulatory Features of the Following Consonants**

Target Word	IPA	Following Consonant	Place of Articulation	Manner of Articulation
gyeolbyeol “breakup”	[kʲɔl.bjɔl]	/p/	Bilabial	Stop
seolmyeong “explanation”	[sɔl.mjɔŋ]	/m/	Bilabial	Nasal
balpo “firing (a gun)”	[pal.pʰo]	/pʰ/	Bilabial	Stop
jeoldo “theft”	[tɛɔl.tɔ]	/t/	Alveolar	Stop
gyeoltak “collusion”	[kʲɔl.tʰak̚]	/tʰ/	Alveolar	Stop
dalseong “achievement”	[tal.sɔŋ]	/s/	Alveolar	Fricative
seoljeong “setting”	[sɔl.tɛɔŋ]	/tɛ/	Alveolo-palatal	Affricate
balchwe “excerpt”	[pal.tɛʰwe]	/tɛʰ/	Alveolo-palatal	Affricate
balgyeon “discovery”	[pal.gjɔn]	/k/	Velar	Stop
beolkeok “bursting”	[pɔl.kʰɔk̚]	/kʰ/	Velar	Stop

### 3.3 Recording

The ten target words were embedded in the carrier sentence “그는 (목적어)를 \_\_\_ 한다” (“He \_\_\_s (the object)”) to elicit natural speech within a controlled syntactic context. The presentation order of the target words was randomized, and each sentence was repeated three times per participant, yielding 30 utterances per speaker.

Recordings were conducted in a sound-attenuated booth. All utterances were recorded in mono at 44.1 kHz sampling rate and 16-bit resolution and saved in uncompressed WAV format. Participants were seated approximately 2-3 cm from the microphone to maintain consistent recording conditions. Any utterance exhibiting disfluency, unnatural prosody, or external noise was immediately repeated to ensure high data quality.

### 3.4 Analysis

Acoustic analysis was conducted using Praat (v.6.4.22). For each token, the rhyme of each syllable, comprising the vowel nucleus and coda /l/, was segmented manually. The onset consonant was excluded from segmentation to isolate the effect of the following consonant on the formant properties of /l/. Based on these segments, the study examined how coda /l/ acoustic realization varied by generation depending on the manner and place of the following consonant. Although duration has often been considered a relevant acoustic parameter in prior studies, it was excluded from the present analysis due to evidence suggesting that duration is not a reliable cue for capturing generational or phonological variation (Jacewicz et al. 2011).

Formant values were extracted at 10 ms intervals using Praat's Burg algorithm, following standard procedures in acoustic analysis. The extracted formant values were imported into R (R Core Team 2024) for analysis and normalized on a time scale from 0 to 1. For statistical modeling, only the latter half of each formant trajectory (0.5-1) was used to minimize the influence of the preceding vowel and focus on the effect of the following consonant. In acoustic terms, lower F2 values or reduced F2-F1 distances typically indicate increased velarization, while lower F3 values or reduced F3-F2 distances indicate retroflexion.

To analyze the nonlinear, time-varying trajectories of F2, F3, and related formant cues, GAMM was fitted using the *mgcv* package in R (Wood 2017). GAMM is suitable for modeling complex, nonlinear patterns in time-dependent acoustic data such as formant trajectories (Wieling 2018, Winter and Wieling 2016). The models included random intercepts for both participants and target words to account for individual anatomical variation and lexical effects. Fixed effects included generation (young vs. old), gender, and the manner and place of articulation of the following consonant. The statistical significance threshold was set at  $\alpha = 0.05$ . Statistical significance in tables is indicated as follows: \*\*\* $p < .001$ , \*\* $p < .01$ , \* $p < .05$ .

## 4. Results

This section examines generational differences in the acoustic realization of Korean coda /l/, analyzed separately for male and female speakers. The analysis further considers how these generational patterns vary according to the manner and place of articulation of the following consonant. Four acoustic measures were examined: F2, F3, F2-F1, and F3-F2. Statistical interpretations are based on the fixed-effect estimates derived from GAMM.

### 4.1 Generational Differences in the Acoustic Realization of Coda /l/

Figure 1 presents the predicted formant trajectories for the younger and older age groups, with shaded areas representing 95% confidence intervals.

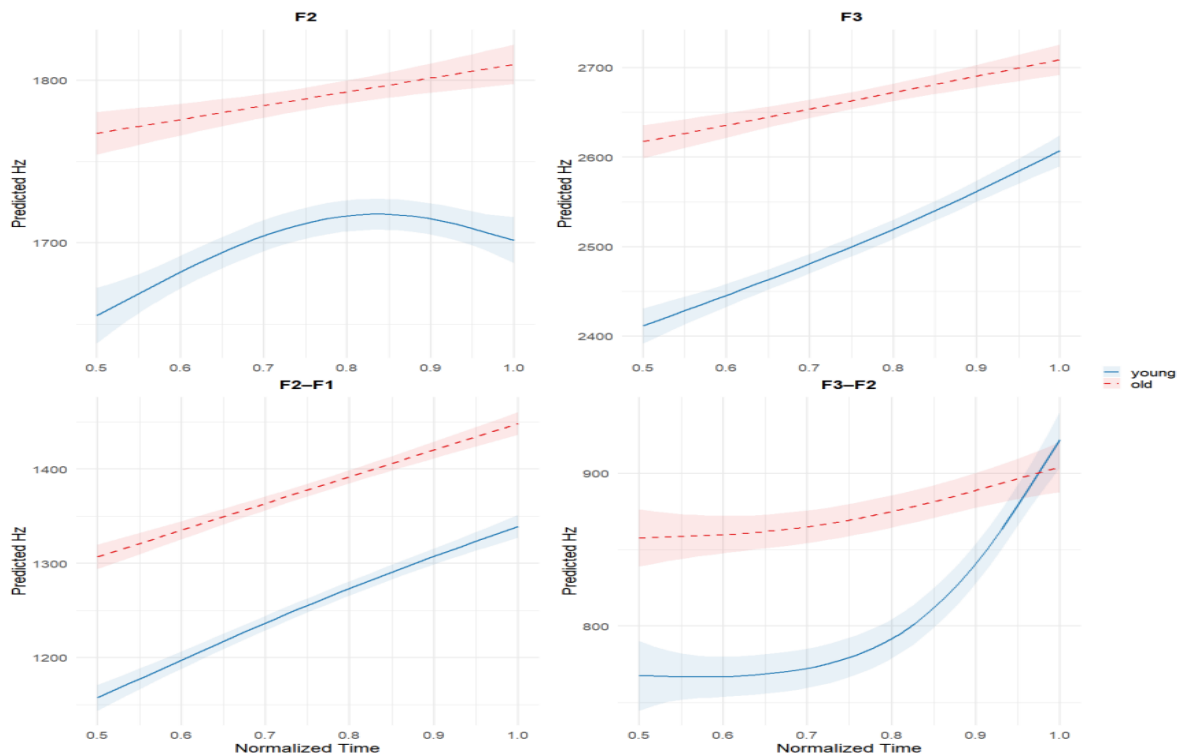


Figure 1. Comparison of /l/ Formant Trajectories (F2, F3, F2-F1, and F3-F2) across Age Groups

As shown in Figure 1, all four formant measures exhibit lower values in younger speakers compared to older speakers. This trend is particularly evident in F2, suggesting a greater degree of velarization among younger speakers. A similar pattern is observed in F2-F1, which serves as a relative index of tongue backness. These results are consistent with the acoustic characteristics reported for dark [ɫ] in English (Mackenzie et al. 2018, Sproat and Fujimura 1993). F3, reflecting retroflexion associated with tongue curling, is markedly lower in younger speakers, further highlighting a generational contrast. However, the difference in F3-F2 between the two groups diminishes toward the end of the trajectory, suggesting a reduced generational difference.

To statistically corroborate these visual patterns, Table 2 presents the fixed-effect estimates from the GAMM analysis for each formant measure, reporting the mean generational differences (in Hz) along with their corresponding level of statistical significance.

Table 2. Fixed-Effect Estimates of Generational Differences in Formant Measures

Formant	$\beta$ (Hz)	SE	$t$	$p$
F2	113.07	45.691	2.475	<0.05*
F3	172.32	61.634	2.796	<0.01**
F2-F1	137.12	40.064	3.423	<0.001***
F3-F2	59.45	46.624	1.275	0.202

The results in Table 2 reveal statistically significant generational differences in F2, F3, and F2-F1. Notably, F2-F1, which serves as an index of velarization, shows a significant difference of 137.1 Hz ( $p < .001$ ), indicating stronger velarization among younger speakers. F3 also differs significantly between generations by 172.3 Hz ( $p$

< .01), suggesting increased retroflexion in the younger speakers. In contrast, the difference in F3-F2 is not statistically significant ( $p = .202$ ), aligning with the trajectory patterns shown in Figure 1, where the generational difference in this measure diminishes toward the latter part of the trajectory. This finding suggests that F3-F2 may be more susceptible to the articulatory influence of the following consonant, resulting in less stable generational differences. Specifically, while a generational difference is evident at the onset, the gap gradually narrows toward the end of the trajectory.

This section examined generational variation in /l/ realization across all tokens, regardless of the articulatory properties of the following consonant. However, previous studies have demonstrated that /l/ realization is highly sensitive to phonological context, particularly to the manner and place of articulation of the following segment (Heselwood and Plug 2011, Recasens 2012). This context sensitivity is also reflected in the variability of the F3-F2 measure. Moreover, the effects of following consonant properties may interact with gender and generation, which may result in more complex pattern of variation.

To further investigate this complexity, section 4.2 presents a fine-grained analysis examining how the place and manner of articulation interact with generation and gender. This approach aims to more accurately identify the articulatory factors that contribute to variation in the acoustic realization of coda /l/.

## 4.2 Effects of Gender and Articulatory Context on Generational Differences in Coda /l/ Realization

### 4.2.1 Generational differences by gender across manner of articulation

Figure 2 illustrates the predicted formant trajectories of coda /l/ for male and female speakers, categorized according to the manner of articulation of the following consonant.

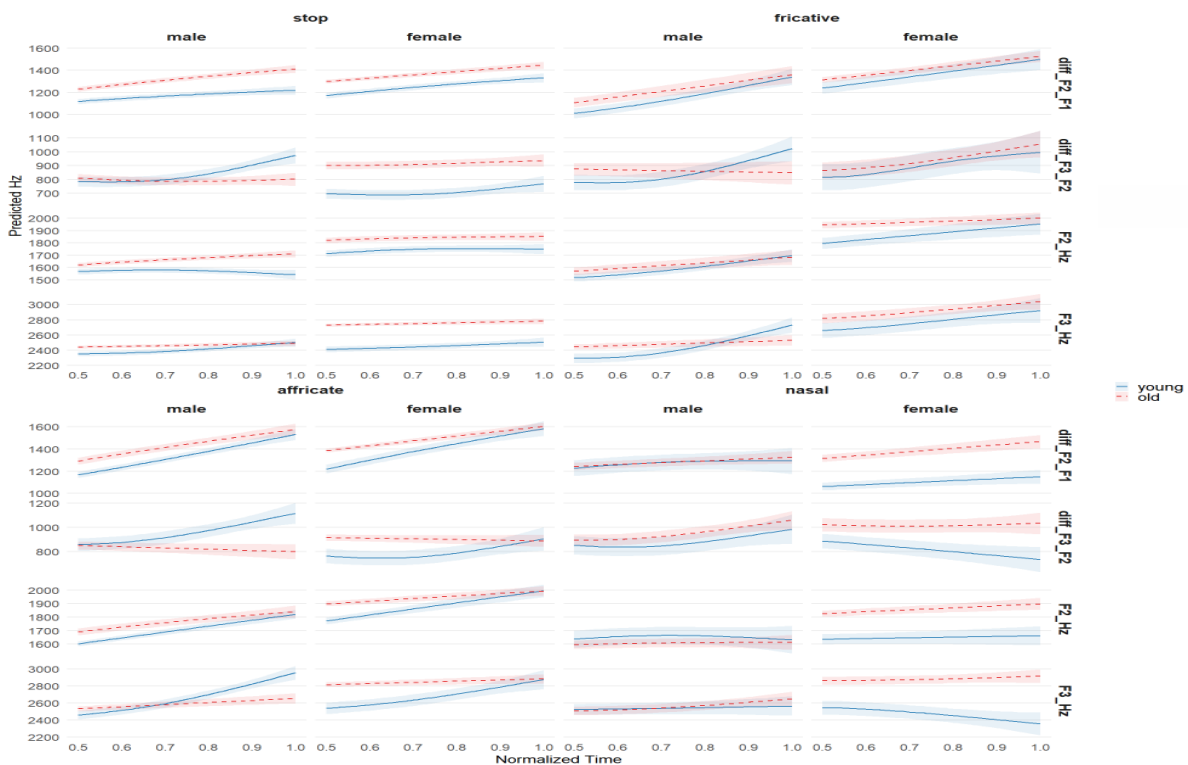


Figure 2. Predicted Formant Trajectories Across Generational Groups, by Gender and Manner of Articulation

According to Figure 2, the generational acoustic differences are more pronounced in female speakers than in male speakers. For F2, female speakers consistently exhibit lower trajectories in the younger generation across all manners of articulation, with the largest gap observed in the nasal context. In contrast, among male speakers, generational differences in F2 are confined to stops and affricates, while in fricative and nasal contexts differences are minimal, and in some cases older speakers even show lower F2 values than younger speakers.

A similar trend is observed for the F2-F1 measure. For female speakers, younger speakers consistently show lower values than older speakers across all environments, indicating stronger velarization in the younger generation. Among male speakers, however, the pattern is less consistent across manners, with generational differences remaining minimal or exhibiting crossing trajectories, suggesting that such differences in velarization are less prominent in males.

F3 trajectories reveal clear generational differences among female speakers across all environments. In contrast, male speakers show minimal or inconsistent generational differences, indicating that the change is more advanced among female speakers. This pattern aligns with the hypothesis of female-led sound change (Eckert 1989, Labov 2001), which proposes that innovative phonetic variants often emerge among women before spreading to the broader speech community.

F3-F2, an index reflecting the degree of retroflexion, also exhibits gender-differentiated patterns. For female speakers, generational differences are pronounced in all manner environments except fricatives, with particularly notable differences in stops and nasals. In contrast, male speakers show less consistent patterns overall. In nasal contexts, trajectories remain relatively stable with minimal intergenerational divergence, while in other environments trajectories tend to fluctuate and cross toward the end of the formant, suggesting that contextual articulatory constraints modulate the apparent generational shift.

These patterns in formant trajectories suggest that generational differences, particularly among female speakers, are both consistent and acoustically salient across manners of articulation. To statistically confirm these findings, Table 3 presents the fixed-effects results from the GAMM for female speakers across manners of articulation.

**Table 3. Fixed-effect Estimates of Generational Differences among Female Speakers, by Manner of Articulation**

Manner	Formant	$\beta$ (Hz)	SE	$t$	$p$
stop	F2-F1	117.06	16.606	7.049	<0.0001***
	F3-F2	197.51	20.649	9.565	<0.0001***
	F2	97.86	16.668	5.871	<0.0001***
	F3	295.70	22.612	13.076	<0.0001***
fricative	F2-F1	63.91	36.822	1.735	0.085
	F3-F2	53.63	42.057	1.275	0.205
	F2	107.19	32.339	3.314	<0.01**
	F3	161.34	49.055	3.289	<0.01**
affricate	F2-F1	83.25	21.647	3.846	<0.0001***
	F3-F2	104.66	34.152	3.064	<0.01**
	F2	59.91	21.076	2.842	<0.01**
	F3	165.46	40.041	4.132	<0.0001***
nasal	F2-F1	289.18	33.696	8.582	<0.0001***
	F3-F2	205.48	41.162	4.992	<0.0001***
	F2	209.37	35.352	5.922	<0.0001***
	F3	414.80	45.468	9.122	<0.0001***

Table 3 summarizes the generational differences in formant measures for female speakers across manners of

articulation. In most environments, younger speakers consistently exhibit lower values for F2, F3, F2-F1, and F3-F2, suggesting greater degrees of velarization and retroflexion, particularly in stop and nasal contexts.

In fricative environments, although generational differences are statistically significant for F2 and F3 ( $p < .01$ ), F2-F1 and F3-F2 do not reach statistical significance ( $p = .085$  and  $.205$ , respectively). This suggests that articulatory gestures associated with velarization and retroflexion are attenuated in fricative contexts. Producing a following fricative requires positioning the tongue tip or blade close to the alveolar ridge and lowering the tongue body to maintain a sufficient aerodynamic channel. These adjustments constrain dorsal retraction and tongue curling. These articulatory limitations may inhibit the realization of velarization and retroflexion, even among younger speakers, who otherwise exhibit these gestures more robustly in other contexts.

While female speakers exhibit consistent generational differences across most manners of articulation, male speakers show a more variable pattern. To examine these patterns in greater detail, Table 4 presents the results of generational comparisons for male speakers.

**Table 4. Fixed-effect Estimates of Generational Differences Among Male Speakers, by Manner of Articulation**

Manner	Formant	$\beta$ (Hz)	SE	$t$	$p$
stop	F2-F1	157.07	16.245	9.668	<0.0001***
	F3-F2	-56.69	19.589	-2.893	<0.01**
	F2	108.87	13.849	7.861	<0.0001***
	F3	52.02	19.030	2.733	<0.01**
fricative	F2-F1	77.76	33.655	2.310	<0.05*
	F3-F2	0.89	39.924	0.022	0.982
	F2	28.71	26.719	1.074	0.285
	F3	28.15	39.787	0.707	0.481
affricate	F2-F1	93.26	21.473	4.343	<0.0001***
	F3-F2	-147.77	34.849	-4.240	<0.0001***
	F2	62.69	20.434	3.068	<0.01**
	F3	-84.93	30.943	-2.744	<0.01**
nasal	F2-F1	14.32	38.934	0.368	0.714
	F3-F2	68.20	42.806	1.593	0.114
	F2	-42.76	37.262	-1.147	0.254
	F3	25.66	52.318	0.490	0.625

Table 4 presents the generational differences in acoustic measures for male speakers across manners of articulation. Compared to female speakers, both the frequency and magnitude of statistically significant differences were generally lower, with generational differences primarily observed in the stop context. In this environment, younger speakers demonstrated lower values in F2 ( $p < .0001$ ), F2-F1 ( $p < .0001$ ), and F3 ( $p < .01$ ), indicating stronger realizations of both velarization and retroflexion. However, the retroflexion index F3-F2 showed a negative coefficient ( $\beta = -56.69$  Hz,  $p < .01$ ), reflecting that F3 was closer to F2 in the older speakers. As illustrated in Figure 2, this pattern is largely attributable to differences in F2: the F2 trajectory of the older speakers gradually rises over time, whereas that of younger speakers declines sharply, consistent with more advanced velarization. Consequently, younger speakers exhibit a higher F3-F2 value due to lower F2, while older speakers show a lower

F3-F2 due to higher F2, resulting in a 56.69 Hz difference between the two groups.

This finding supports Recasens' (2012) claim that, when using F3-F2 as an index of retroflexion, one must consider not only the magnitude between the formants but also the directionality of the trajectory and absolute values of both F2 and F3. Therefore, the lower F3-F2 value in the older speakers should not be interpreted as direct evidence of retroflexion, but rather as a relative acoustic effect of reduced tongue body retraction.

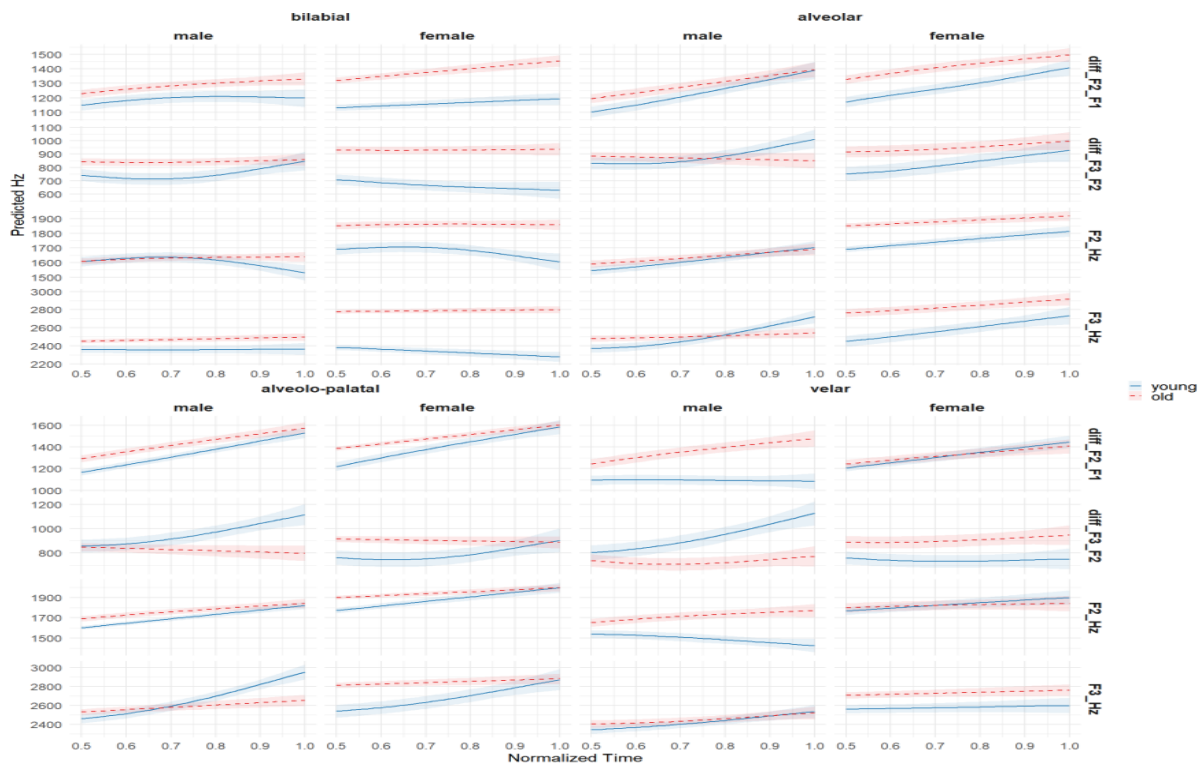
The articulatory characteristics of fricatives, particularly positioning the coronal near the alveolar ridge and lowering the tongue body to maintain airflow, can constrain the realization of /l/ velarization and retroflexion. This tendency is also evident in Figure 2, where the presence of a following fricative results in a rise in both F2 and F3 trajectories. F3 shows a notably greater rise in younger speakers, indicating that even younger males, who otherwise display more advanced sound change, find it difficult to realize retroflexion in fricative contexts. This suggests that retroflexion is more strongly inhibited than velarization in these environments. Consequently, most measures (F2, F3, and F3-F2) show no statistically significant generational differences among male speakers.

In affricate environments, generational differences were statistically significant for all measures. Younger speakers consistently exhibited lower F2 and F2-F1 values, indicating stronger velarization. Meanwhile, F3-F2 was lower in the older speakers (-147.77 Hz), a pattern attributable to a pronounced late-stage rise in the F2 trajectory of younger speakers. This resulted in an F3 value 84.93 Hz higher in the older group. These findings suggest that retroflexion is also constrained in affricate environments, with younger speakers particularly affected because their more advanced tongue retraction conflicts more strongly with the narrow constriction required for affricates. This generational difference in articulatory sensitivity highlights how segmental constraints can shape, and sometimes counteract, the trajectory of phonetic change.

Finally, in the nasal context, none of the formant measures showed statistically significant generational differences among male speakers, indicating that in this environment generational effects on velarization and retroflexion are minimal. This likely reflects persistent articulatory constraints imposed by the bilabial nasal /m/ ('*seolmyeong*'), which inhibits tongue body retraction and pharyngeal expansion. Whereas male speakers appear to preserve these constraints across generations, female speakers appear to implement compensatory articulatory strategies, resulting in measurable acoustic shifts. This gender asymmetry highlights the interplay between articulatory limitations and sociophonetic dynamics in shaping sound change.

#### 4.2.2 Generational differences by gender across place of articulation

Figure 3 shows the predicted formant trajectories for male and female speakers, illustrating how generational differences in the realization of coda /l/ are conditioned by the place of articulation of the following consonant.



**Figure 3. Predicted Formant Trajectories Across Generational Groups, by Gender and Place of Articulation**

Among male speakers, generational differences were more restricted to specific places of articulation than those observed for female speakers. In the bilabial and alveolo-palatal contexts, certain acoustic indices showed intergenerational variation; however, the magnitude of change was smaller than that observed in female speakers, and the overall trajectory shapes remained relatively conservative. In the alveolar context, most measures showed minimal or no generational difference. In contrast, in the velar context, younger speakers exhibited accelerated F2 lowering in the latter part of the trajectory, resulting in a significant generational difference in the F2-F1 measure, indicative of increased velarization. Nevertheless, due to articulatory constraints inherent to velar segments, F3 values remained largely stable across generations. Consequently, the F3-F2 index displayed a reversed pattern, with younger speakers exhibiting higher values than older speakers. This pattern appears to result not from increased retroflexion, but rather from a greater degree of F2 lowering in younger speakers.

In summary, Figure 3 demonstrates that the place of articulation of the post-liquid consonant significantly conditions the acoustic realization of /l/, with generational differences being more pronounced among female speakers. These findings support the interpretation that both velarization and retroflexion are subject to gender-asymmetric generational change, with female speakers exhibiting more advanced stages of this phonetic shift.

These trajectory patterns are further corroborated by the fixed-effects estimates in Table 5, which provide detailed evidence of generational differences across places of articulation among female speakers.

**Table 5. Fixed-effect Estimates of Generational Differences among Female Speakers, by Place of Articulation**

Place	Formant	$\beta$ (Hz)	SE	$t$	$p$
bilabial	F2-F1	226.46	19.142	11.830	<0.0001***
	F3-F2	271.05	23.577	11.496	<0.0001***
	F2	186.03	17.486	10.639	<0.0001***
	F3	457.13	25.206	18.135	<0.0001***
alveolar	F2-F1	135.56	18.198	7.449	<0.0001***
	F3-F2	112.24	32.330	3.471	<0.0001***
	F2	136.08	17.256	7.885	<0.0001***
	F3	248.3	35.811	6.934	<0.0001***
alveolo-palatal	F2-F1	83.25	21.647	3.846	<0.0001***
	F3-F2	104.66	34.152	3.064	<0.01**
	F2	59.91	21.076	2.842	<0.01**
	F3	165.46	40.041	4.132	<0.0001***
velar	F2-F1	-1.19	36.887	-0.032	0.974
	F3-F2	163.30	35.272	4.629	<0.0001***
	F2	-15.67	39.603	-0.395	0.693
	F3	147.90	37.783	3.914	<0.0001***

Table 5 presents the generational differences in acoustic measures for female speakers according to the place of articulation of the following consonant, based on fixed-effect estimates ( $\beta$ ) and associated  $p$ -values. Statistically significant generational differences were observed across all acoustic indices in bilabial, alveolar, and alveolo-palatal contexts.

However, the velar context showed a distinct pattern. No significant generational difference was observed for F2 ( $p = .693$ ), likely reflecting the articulatory influence of the following velar consonant, which inherently favors maximal tongue dorsum retraction and thus provides limited scope for additional velarization of the preceding /l/. Accordingly, F2-F1 also failed to reach statistical significance. By contrast, younger speakers exhibited significantly lower F3 and F3-F2 values, indicating that retroflexive articulatory features are more advanced among the younger generation in this context. This suggests that, within the same place of articulation, retroflexion and velarization are affected differently across generations.

In summary, female speakers exhibited consistent generational differences across acoustic measures, most pronounced in bilabial and alveolar contexts and weaker in alveolo-palatal and velar contexts. This pattern reflects the increasing articulatory constraints associated with more posterior places of articulation, which inherently limits further velarization or retroflexion of /l/.

In contrast, male speakers displayed a more restricted and variable pattern of change. Table 6 presents the fixed-effects estimates for male speakers, illustrating how generational variation differs by place of articulation.

**Table 6. Fixed-effect Estimates of Generational Differences among Male Speakers, by Place of Articulation**

Place	Formant	$\beta$ (Hz)	SE	$t$	$p$
bilabial	F2-F1	101.93	20.410	4.994	<0.0001***
	F3-F2	87.66	23.194	3.779	<0.0001***
	F2	35.59	17.569	2.026	<0.05*
	F3	123.28	27.791	4.436	<0.0001***
alveolar	F2-F1	52.16	20.914	2.494	<0.05*
	F3-F2	-29.59	24.143	-1.225	0.221
	F2	16.15	16.511	0.978	0.329
	F3	-13.35	25.307	-0.527	0.598
alveolo-palatal	F2-F1	93.26	21.473	4.343	<0.0001***
	F3-F2	-147.77	34.849	-4.240	<0.0001***
	F2	62.69	20.434	3.068	<0.01**
	F3	-84.93	30.943	-2.744	<0.01**
velar	F2-F1	285.08	29.875	9.542	<0.0001***
	F3-F2	-217.67	38.201	-5.698	<0.0001***
	F2	235.13	26.433	8.895	<0.0001***
	F3	17.50	30.898	0.566	0.572

Table 6 presents the generational differences in acoustic measures for male speakers across four places of articulation. Compared to female speakers, generational variation among male speakers was more limited and context-dependent, with both the magnitude and statistical significance of acoustic differences differing by place of articulation. Notably, the bilabial context yielded the most robust effects, with all four measures reaching statistical significance.

In the alveolar context, only F2-F1 showed a statistically significant difference ( $p < .05$ ), while the other measures failed to reach significance. This pattern suggests that, unlike female speakers, male speakers exhibited only limited generational differences in the realization of velarization in this context, likely because producing /l/ before an alveolar consonant requires the tongue tip or blade to be positioned near the alveolar ridge, thereby constraining tongue dorsum retraction or tongue curling associated with velarization and retroflexion. Consequently, even the observed F2-F1 difference was smaller than that found in other places of articulation. In contrast, female speakers appear to employ compensatory articulatory strategies that allow generational differences to emerge even under such constraints.

In the alveolo-palatal context, all acoustic measures showed generational differences. Notably, both F3 and F3-F2 exhibited negative  $\beta$  coefficients ( $\beta = -84.93$  and  $\beta = -147.77$ , respectively), indicating that younger speakers had higher F3 and F3-F2 values than older speakers. This pattern likely results from a steep rise in F3 toward the end of the trajectory among younger speakers. These results suggest that the alveolo-palatal context constrains retroflexion of the preceding /l/, thereby limiting its realization as the tongue transitions to the following consonant. In contrast, older speakers generally produce more conservative realizations of /l/, which reduces the degree of conflict and makes the constraint less evident, resulting in a smaller F3 shift. The greater F3-F2 observed in younger speakers may thus reflect their accommodation strategy to this constraint, whereas older speakers rely on more stable, conservative articulations.

In the velar context, younger speakers showed markedly greater dorsal retraction, as indicated by a significantly lower F2. However, no generational difference was observed in F3 ( $p = .572$ ), indicating that retroflexion did not differ significantly across generations. Consequently, the retroflexion index F3-F2 was significantly higher in younger speakers ( $\beta = -217.67$ ), driven primarily by their lower F2 rather than by changes in F3. This pattern suggests a partial decoupling of dorsal and coronal components in velar contexts and highlights the need for caution in interpreting an increased F3-F2 as evidence of reduced retroflexion, particularly when it is primarily driven by a sharp lowering of F2 without notable F3 change.

In summary, male speakers exhibited more limited generational differences, which varied according to the place of articulation. Statistically significant differences, characterized by lower values in younger speakers, were observed only in the bilabial context, where all four acoustic measures reached significance. In other environments, generational differences were small, nonsignificant, or even reversed. These findings suggest that male speakers are more sensitive to place-specific articulatory constraints, particularly in environments that inhibit the realization of velarization or retroflexion. Compared to female speakers, male speakers displayed more restricted and context-dependent realizations of coda /l/, with generational changes more strongly conditioned by articulatory limitations.

## 5. Discussion and Conclusion

This study investigates generational and gender-based variation in the acoustic realization of Korean coda /l/, focusing on how the manner and place of the following consonant conditions velarization and retroflexion. To capture fine-grained patterns beyond the scope of static point estimates, the full formant trajectories (F2, F3) and relative indices (F2-F1, F3-F2) were analyzed using Generalized Additive Mixed Model (GAMM). This trajectory-based, multidimensional approach provides a comprehensive account of variation in Korean coda /l/ across articulatory contexts.

The results indicate that younger speakers exhibit more advanced velarization and retroflexion than older speakers, yielding lower values across all acoustic measures. They also reveal clear gender asymmetries shaped by articulatory properties of the following consonant. Female speakers show consistent generational differences across most manners of articulation, with younger speakers exhibiting greater velarization and retroflexion, particularly in stops and nasals, although these gestures are suppressed in fricative contexts. In contrast, male speakers display fewer and more context-specific differences, primarily restricted to stops and affricates, with minimal or statistically nonsignificant generational differences in fricative and nasal contexts, likely due to stronger articulatory constraints. Their realizations are particularly sensitive to the manner of the following consonant, and in stop and affricate contexts, this sensitivity produces sharp shifts in F2 and F3 trajectories, sometimes reversing the expected generational pattern. This suggests that, especially among younger male speakers, articulatory constraints exert greater influence than the maintenance of velarization and retroflexion. Furthermore, the place of articulation influences this trajectory. Female speakers exhibit robust generational differences in bilabial, alveolar, and alveolo-palatal contexts, while in velar contexts, generational differences are limited to subtle retroflexion. For male speakers, significantly lower values across all measures for younger speakers, relative to older speakers, are observed only in the bilabial context.

Overall, these results indicate that the observed patterns reflect a broader generational shift whose progression differs systematically by gender. This shift is more advanced and consistent among female speakers, whereas male speakers' realizations are more constrained by segmental context. This supports the gender-differentiated diffusion theory (Eckert 1989, Labov 2001), which posits that sound change originates with female speakers and gradually

diffuses to male speakers. Younger speakers produce Korean coda /l/ with lower F2 and F3 values, indicative of darker, more retroflex-like realizations. This pattern aligns with Park and Jang's (2016) observation of higher F2 and slightly lower F3 in Korean learners' English laterals and is consistent with cross-language phonetic drift (Chang 2010, Sancier and Fowler 1997). This is further supported by the convergence of time-aligned trajectory patterns with imaging evidence (Lee et al. 2015, Lim et al. 2023), demonstrating that lateral production involves context-sensitive coordination of tongue-tip and tongue-body gestures.

Building on these findings, the pronounced generational shifts among female speakers may be interpreted as reflecting the sociolinguistic tendency in which women often spearhead phonetic innovation. Increased exposure to English through formal education and global media may have accelerated phonetic drift among younger Koreans toward English-style dark laterals, especially in contexts with fewer articulatory constraints. Velarization and retroflexion tend to emerge in articulatorily less complex contexts and gradually spread to more complex ones, aligning with the principle of articulatory economy (Browman and Goldstein 1992, Lindblom 1990). This pattern may further reflect the sociolinguistic prestige associated with English-linked dark laterals (Lewis and de Leeuw 2025, Sim 2023).

Despite its contributions, this study has limitations that warrant caution in interpretation. First, the analysis of nasal and fricative contexts relied on a single token with a following bilabial nasal (/m/) and alveolar fricative (/s/), which limits the generalization of the findings. Second, all participants were recruited exclusively from the Gyeongsang dialect region. Given the substantial dialectal variation in Korea, other regional varieties may exhibit distinct patterns of /l/ velarization and retroflexion. Nonetheless, this study provides a comprehensive account of generational variation in Korean coda /l/ by employing continuous formant trajectory analysis and examining both dorsal and coronal articulatory components across diverse segmental contexts. This approach offers a finer-grained understanding of the acoustic mechanisms underlying liquid variation and advances sociophonetic research on sound change.

To address these limitations, future research should examine a broader range of nasal contexts using a larger lexical set. It should also compare groups of participants, including speakers from outside the Gyeongsang region, stratified by the duration and intensity of English exposure to more precisely assess whether the female-led changes observed here are contact-induced. To this end, integrating real-time ultrasound tongue imaging (UTI) and electropalatography (EPG) with acoustic analysis will facilitate linking dynamic formant patterns to tongue-palate contact gestures, thereby clarifying the mechanisms underlying the variations of Korean coda /l/. Taken together, this approach is expected to enhance our understanding of the factors driving the observed changes in the realization of coda /l/ in Korean.

## References

- Ahn, M. 2017. An acoustic study of the word-final lateral approximant in Korea. *Language Research* 53, 231-245.
- Browman, C. P. and L. Goldstein. 1992. Articulatory phonology: An overview. *Phonetica* 49, 155-180.
- Chang, C. B. 2010. *First Language Phonetic Drift During Second Language Acquisition*. Doctoral dissertation, University of California, Berkeley.
- Chung, H. 2021. Acoustic characteristics of pre- and post-vocalic /l/: Patterns from one southern white vernacular English. *Language and Speech* 65(2), 513-528.
- Crosby, D. and A. Dalola. 2021. Phonetic variation in the Korean liquid phoneme. *Proceedings of the Linguistic Society of America* 6(1), 701-712.

- Eckert, P. 1989. The whole woman: Sex and gender differences in variation. *Language Variation and Change* 1(3), 245-267.
- Espy-Wilson, C. Y. 1992. Acoustic measures for linguistic features distinguishing the semivowels /wɹl/ in American English. *Journal of the Acoustical Society of America* 92(2), 736-757.
- Heselwood, B. 2009. Rhoticity without F3: Lowpass filtering, F1-F2 relations and the perception of rhoticity in NORTH-FORCE, START and NURSE words. *Leeds Working Papers in Linguistics and Phonetics* 14, 49-64.
- Heselwood, B. and L. Plug. 2011. The role of F2 and F3 in the perception of rhoticity: evidence from listening experiments. In *Proceedings of the 17th International Congress of Phonetic Sciences (ICPhS)*. City University of Hong Kong, 867-870.
- Hwang, Y., S. Charles and S. M. Lulich. 2019. Articulatory characteristics and variation of Korean laterals. *Phonetics and Speech Sciences* 11(1), 19-27.
- Jacewicz, E., R. A. Fox and J. Salmons. 2011. Cross-generational vowel change in American English. *Language Variation and Change* 23(1), 45-86.
- Kang, H. S. 1999. Production and perception of English /r/ and /l/ by Korean learners of English: An experimental study. *Speech Science* 6(1), 21-38.
- Kirkham, S. 2017. Ethnicity and Phonetic Variation in Sheffield English Liquids. *Journal of the International Phonetic Association* 47(1), 17-35.
- Koffi, E. 2024. A comprehensive review of the acoustic correlate of duration and its linguistic implications. *Linguistic Portfolios* 13(2). 1-28.
- Labov, W. 1994. *Principles of Linguistic Change, Volume I: Internal Factors*. Wiley-Blackwell.
- Labov, W. 2001. *Principles of Linguistic Change, Volume II: Social Factors*. Wiley-Blackwell.
- Lee-Kim, S. I., L. Davidson and S. Hwang. 2013. Morphological effects on the darkness of English intervocalic /l/. *Laboratory Phonology* 4(2), 475-511.
- Lee, Y. J., L. M. Goldstein and S. S. Narayanan. 2015. Systematic variation in the articulation of the Korean liquid across prosodic positions. In *Proceedings of the 17th International Congress of Phonetic Sciences (ICPhS)*. Glasgow, UK.
- Lewis, S. and de Leeuw, E. 2025. An acoustic and articulatory investigation into Liverpool and Wirral lateral production in female and male adolescent speech: Covert articulatory variation in ‘Scouse’ and Wirral speech. *English Today*, 1-17.
- Lim, N., A. Kochetov and Y. Kang. 2023. Articulation and acoustics of Korean liquids: A case study in loanword adaptation. *Canadian Acoustics* 51(3), 208-209.
- Lindblom, B. 1990. Explaining phonetic variation: A sketch of the H&H theory. In W. J. Hardcastle and A. Marchal, eds., *Speech Production and Speech Modelling*, 403-439. Kluwer.
- Mackenzie, S., E. Olson, M. Clayards and M. Wagner. 2018. North American /l/ both darkens and lightens depending on morphological constituency and segmental context, *Laboratory Phonology* 9(1), 13.
- Park, S. and T. Y. Jang. 2016. Acoustic characteristics of English liquids produced by Korean learners of English. *Studies in Phonetics, Phonology, and Morphology* 22(2), 289-315.
- R Core Team. 2024. R: A language and environment for statistical computing. R Foundation for Statistical Computing.
- Recasens, D. 2012. A cross-language acoustic study of initial and final allophones of /l/. *Speech Communication* 54(3), 368-383.
- Sancier, M. L. and C. A. Fowler. 1997. Gestural drift in a bilingual speaker of Brazilian Portuguese and English.

*Journal of Phonetics* 25, 421-436.

- Sim, J. H. 2023. Negotiating social meanings in a plural society: Social perceptions of variants of /l/ in Singapore. *English. Language in Society* 52(4), 617-644.
- Sohn, H. S. 2008. Phonological contrast and coda saliency of sonorant assimilation in Korean. *Journal of East Asian Linguistics* 17(1), 33-59.
- Song, I. 2020. Generational and gender differences of word-initial fortis from voiced obstruents in English loanwords. *Korean Linguistics* 89, 199-222.
- Sóskuthy, M. 2017. Generalised additive mixed models for dynamic analysis in linguistics: a practical introduction. 10.48550/arXiv.1703.05339.
- Sproat, R. and O. Fujimura. 1993. Allophonic variation in English /l/ and its implications for phonetic implementation. *Journal of Phonetics* 21(3), 291-311.
- Tagliamonte, S. A. and A. D'Arcy. 2009. Peaks beyond phonology: Adolescence, incrementation, and language change. *Language* 85(1), 58-108.
- Turton, D. 2017. Some /l/s are darker than others: Accounting for variation in English /l/ with ultrasound tongue imaging. *U. Penn Working Papers in Linguistics* 20(2), 189-198.
- Turton, D. and R. Lennon. 2023. An acoustic analysis of rhoticity in Lancashire, England. *Journal of Phonetics* 101, 101280.
- Wieling, M. 2018. Analyzing dynamic phonetic data using generalized additive mixed modeling: A tutorial focusing on articulatory differences between L1 and L2 speakers. *Journal of Phonetics* 70, 86-116.
- Winter, B. and M. Wieling. 2016. How to analyze linguistic change using mixed models, Growth Curve Analysis and Generalized Additive Modeling. *Journal of Language Evolution* 1(1), 7-18.
- Wood, S. N. 2017. *Generalized Additive Models: An Introduction with R (2nd ed.)*. Chapman & Hall/CRC.
- Yun, E., H. Sim, S. Park, H. Kim and J. Kang. 2017. Comparison of the pronunciation of word-initial liquids between generations in Korean. *Phonetics and Speech Sciences* 9(3), 7-15.

Examples in: Korean

Applicable Languages: Korean

Applicable Level: Tertiary